Long Term Monitoring of Camping Beaches In Grand Canyon

Summary of Results for Years 2006 – 2007 with Comparisons to Pre 1996 Beach Building/Habitat Flow and the Pre 2004 High Experimental Flow Beaches

Annual Report of Repeat Photography
By Grand Canyon River Guides, Inc.[1]
(Adopt-A-Beach Program)

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Adopt – A – Beach:
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Summary of Results for Years 2006 – 2007

Introduction and Methods

The Adopt-A-Beach (AAB) program has now completed its twelfth year as a study that monitors camping beaches along the Colorado River in Grand Canyon. This program, sponsored by Grand Canyon River Guides, Inc., is implemented by a 100% volunteer group of river guides, scientists and NPS personnel. Results are submitted to various agencies such as the Cultural Resources Program of the Grand Canyon Monitoring and Research Center (GCMRC) and Grand Canyon National Park. Results are also presented to the Adaptive Management Program so that private and commercial recreational interests are represented as stakeholders in Colorado River management as reported to the Secretary of the Interior.

Methods implement repeat photography and observational comments that document a selected set of camping beaches in Grand Canyon. Data collection is usually conducted from April through October of the year, though data has been gathered through December and as early as February in some years. The selected beaches are categorized as belonging within one of five different critical reaches within the river corridor (Glen Canyon, Marble Canyon, Upper Granite Gorge, Muav Gorge and the Lower Granite Gorge). A critical reach is defined as an extended area in which camping beaches are sparse, small, and/or in high demand.

The program assesses visible photographs and first-hand, objective comments pertaining to changes to beaches, as influenced by regulated flow regimes, rainfall, wind, vegetation and human impacts. Volunteers for this program are unique in that many run the Colorado River more than once in one season, and are able to provide sets of repeat photographs and on-the-spot comments for each study beach. To date, river runners have produced almost 2000 repeat photographs and associated field sheets recording the sequential condition of beaches. Research results include changes to beaches after being impacted by certain flow regimes, longevity of the 1996 Beach Habitat/Building Flow (BHBF) and 2004 High Experimental Flow (HEF) deposits and primary and secondary processes that cause change in camping beach area and quality.

Results and General Conclusions

Results of this study show that beaches have continued to decrease in size and quality, system wide, since 1996. As of the end of 2007, 33% of the beaches reviewed (12 of 36) were classified as being degraded compared to the same beaches examined in 1996. The factor considered to be the primary contributor of long-term erosion is fluctuating flows that contain low sediment concentrations. This is especially evident for a period immediately following a BHBF or HEF event. This is followed by a decreased magnitude of change that reflects two geomorphic processes:1) the increased stability of beach fronts as they attain an angle of repose, and 2) decreased amounts of sediment that can be eroded from beaches (Thompson, 2004). The angle of repose is achieved as the beach recedes to a point static with the erosive force of the water. This recession is directly related to the amount of river flow and the geography of the surrounding canyon near an individual beach.

Independent of low sediment concentration flows is the loss of camp area at a beach through the action of rain created gullies. Rainfall funneled onto a beach by tributaries or the surrounding rock walls is recorded in at least 15 instances during 2006 and 2007, and has been the second most often cited cause of erosion in the two previous years of study (Thompson and Pollock, 2006, Lauck, 2007). Unlike the decrease in magnitude of erosion from fluctuating flows, flash events are less predictable in their frequency and vary considerably in their effects. Any single event can prove devastating to a beach, as happened at Olo, RM 145.6L in recent years, and the erosion effects appear to be accumulative, as experienced at Matkat Hotel, RM 148.5L in 2006 and 2007.

Vegetation encroachment is a less dramatic and less frequent factor in beach change, though reduced camp area and camp desirability due to vegetation, particularly arrowweed and camelthorn, were commented on by adopters.

Changes in beaches due to eolian action is another of the lesser emphasized contributors to beach adjustment. Though not cited as a cause for change in beach classification during this study, sand removal and repositioning on beaches by wind was discernable. The same can be said for human impacts.

The data accumulated for 2006 and 2007 emphasize the need for continued BHBF events whenever the sediment load available in the system allows, followed by low fluctuating flows. The flows that exceed power plant capacity are vital in replacing beach areas above the 30000 cfs line where sand has been removed by flash floods, restoring beach fronts eroded by river and wave action and to help mitigate the effects of vegetation encroachment and eolian erosion.

We thank the Grand Canyon Conservation Fund for their ongoing support of the Adopt-a-Beach program, including the 2006/2007 analysis. The Grand Canyon Conservation Fund is a non-profit, grant-making organization, managed by the Grand Canyon River outfitters and fueled by donations made primarily by the outfitted public who visit the Grand Canyon via professionally outfitted river trips. We also thank individual GCRG members who contributed to this program. And of course, this program would not have been possible without the considerable work of the volunteer adopters who fuel this program through their stewardship efforts.

For questions or comments please contact Paul Lauck or Lynn Hamilton at Grand Canyon River Guides, Inc., Flagstaff, Arizona (928)-773-1075.

INTRODUCTION

In 1981, the Glen Canyon Environmental Studies (GCES), under the administration of the Bureau of Reclamation, began to study the effects of controlled flow releases from the dam on the downstream river ecosystem (U.S. Department of Interior 1987). Included in this study were effects on sediment supply and recreational resources. Studies of sediment dynamics showed that fluctuating flow releases from the dam have had a degrading effect on sand bar deposits (Hazel and others 1993, Schmidt and Graf 1990) since the closure of the dam. However, beaches can also be replenished by high flows adequate to entrain bedload sand and cause deposition to high elevation areas of beaches (Parnell and others 1997, Wiele and others 1999). Studies of campsite resources demonstrated that the impact to sand bars due to erosion decreases the carrying capacity and campable area available for river parties and backpackers (Kearsley and Warren 1993, Kearsley and Quartaroli 1997).

In 1992, the Grand Canyon Protection Act was passed by Congress to ensure that ecological and cultural resources downstream of the dam would be monitored for changing conditions imposed by operation of the dam states that the dam:

"….must be managed in such a way as to protect, mitigate adverse impacts to, and improve the values for which Grand Canyon National Park….were established, including, but not limited to, natural and cultural resources and visitor use" (U.S. Department of Interior 1996).

The Grand Canyon Dam Environmental Impact Statement recommends that scheduled, high-flow releases of short duration be periodically implemented (U.S. Department of Interior 1995). Sand bars form when sediment carried by the river, either from bed load or suspended load, is deposited by the action of eddy currents in recirculation zones. This occurs primarily on the downstream end of debris fans, but also in areas along the river's channel margin (Schmidt 1990). Habitat Maintenance Flows (HMF) are within power plant capacity (31,500cfs), whereas those above this discharge are described as Beach/Habitat Building Flows (BHBF) or High Experimental Flows (HEF). The former were intended to maintain existing camping beaches and wildlife habitat; the latter to more extensively modify and create sand bars, thus restoring some of the dynamics that resulted from flooding in the ecosystem.

The Adopt-A-Beach Program (AAB) was begun in the Spring of 1996 as a means to monitor the condition of camping beaches along the Colorado River in Grand Canyon through repeat photography. Implemented by the Grand Canyon River Guides, Inc., (GCRG) a nonprofit, grassroots organization that represents the interests of the Grand Canyon river running community, this program is conducted by the volunteer efforts of river guides (including commercial, private and scientific groups) who travel by boat on the Colorado. Those who run the river are interested in observing how dam controlled flows, rain and wind created erosion, human use and other factors impact the camping beaches along the Colorado. These factors have been addressed throughout the continued period of this study, 1996-2007, as river runners have observed changes to the beaches and have recorded this information through repeat photography and written comments associated with each photograph.

Inception of Adopt-A-Beach was a result of the first BHBF of 45,000 cfs in the Spring of 1996. Specifically, the AAB program was launched by GCRG prior to the BHBF to document the effects of the high flow on camping beaches. River runners photographed and recorded information about changing conditions prior to the high flow, just after the high flow, and throughout the 1996 river season. The overall conclusion of that study demonstrated that the BHBF was highly effective in depositing new high-elevation sand, but that the post-BHBF high steady summer flow schedules caused rampant erosion of sand bars (Thompson and others 1997).

Camping beaches are an important resource for river parties conducting trips through Grand Canyon. Both commercial and private river trips, as well as backpackers, rely on wide sandy areas for camping and recreation. As a way to contribute to resource management, AAB now submits annual results to the Adaptive Management Program. The results and conclusions are synthesized through a representative that serves on the Technical Work Group (TWG) board. Professional river guides and other river runners make the program possible, contributing 100% of the manpower, the entire dataset of repeat photographs, and valuable input about the condition of beaches throughout each season and between years. Monitoring includes information on natural and human-induced impacts to beaches such as cutbank retreat, wind erosion and dune formation, rain gully formation and the effects of visitation and camping. The purpose of this report is to present the cumulative findings of data specific to this program through the commercial boating season of 2007.

During November 2004, an HEF of 42,000 cfs occurred. The river season of 2005 then witnessed a high daily fluctuating flow regime of 5000-20,000 cfs beginning January 3 and continuing into early April. This flow regime is known as the Winter High Fluctuating Flow (WHFF), or Trout Suppression Flow (TSF) for one of its intended aims. This high fluctuating flow schedule was resumed from early December of 2005 through February 2006, and also for December 2006 and January 2007, with daily flows averaging between 9000+ cfs and 16000+ cfs. Periods of high fluctuating flows were also documented for June through September in both years, with daily averages usually between 10000 cfs and 18000 cfs. No steady flow activities were conducted in either year, but the fluctuating flow releases during the remainder of the year were lower in magnitude and variable from month to month. Specific research questions posed for the two years in the current study target:

- What changes in beaches occurred during the winters of 2005-2006 and 2006-2007?
- What changes in beaches occurred from the early spring to late fall months of 2006 and 2007?
- How do the beaches compare between the end of 2007 and immediately preceding the 1996 flood?
- How do the beaches compare between the end of 2007 and immediately preceding the 2004 flood?
- Which processes resulting in change were most prevalent?
- Were there differences in these results per each critical river reach?
- Based on these results, what does the AAB program conclude about future resource management of campsite beaches?

Through analysis of photos and data sheets completed by the guides, this report attempts to answer these questions.

METHODS

Data Collection

The primary method of assessing camping beaches in this study is through analysis of repeat photography. The majority of these photographs are collected between March and October, when volunteers (river guides, scientists, GCNP personnel) photographed a specific "adopted" beach every time they pass through the river corridor. Disposable waterproof cameras and data sheets, provided by GCRG, are distributed to all adopters of beaches. At the end of the commercial season (October/November), adopters mail cameras and data sheets back to GCRG for analysis. A qualified scientist, who is active in Grand Canyon issues and is familiar with AAB study sites, is contracted from year to year to analyze photographs and data, draw up results and offer conclusions to resource managers concerned with recreational and cultural interests in Grand Canyon.

This project allows each participant to take stewardship of a site, and enables him or her to detect ongoing changes over the course of a season. During each visit, guides photograph their adopted beach from pre-established photo locations that provide different views of the beach: specifically, the beachfront and an overview of the camp. In sites where overviews are impossible, a photo location is selected to reveal as much of the camp as possible. In the last 6 years, however, thick tamarisk encroachment has led to recent re-establishment of many photo locations. Re-establishment of photo locations will be on-going as needed, in order to obtain the necessary photo angles.

A data sheet (Appendix A) accompanying each photographed visit allows the adopter to comment on changes to the condition of the beach and the possible causes of changes that are visible. Also included are site location, date, time, and approximate river flow. Photographed visits for each beach average 4 per season. The number of visits for each beach can range from one to eight or more. Many guides take the initiative to also photograph different episodic events such as debris flow or flash flooding that recently occurred on or near their beach and other evidence to support their comments on the datasheets. Such photos can be highly beneficial to many different researchers concerned with monitoring a particular resource at a given area.

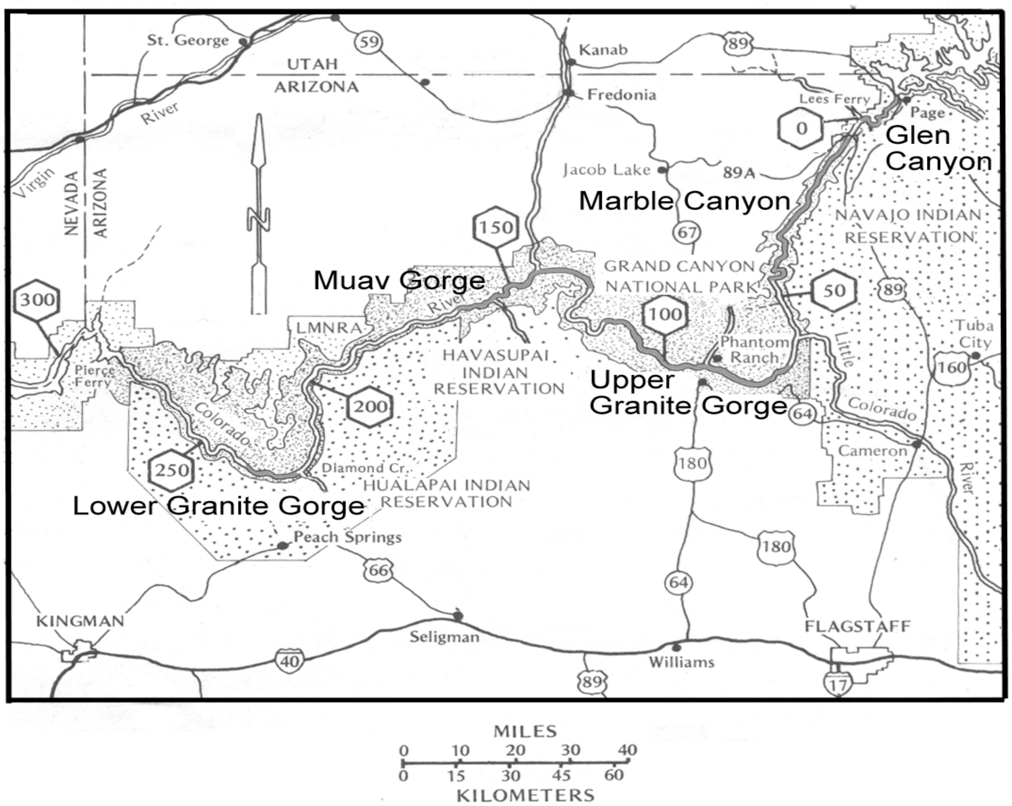
The photographs for all beaches of all years have been carefully labeled and are physically archived at the Grand Canyon River Guides office. Photographs from years 1996 through 2007 have been archived digitally onto compact discs which can be obtained from the GCRG office or the GCMRC library.

Information gleaned from photographs and from data sheets are entered into a master database using Access 2000. A cross check of the two different sources of information help to fill gaps in data and help to standardize changes from one visit to the next. For instance, if guide comments lack information about a site at the time a photograph was taken, the photo is used to assess the site for that visit. If the photo reveals little information and the guide's data sheet provides enough descriptive information about conditions throughout the site, the comments receive priority. The current Access database contains over 1,900 records of assessed changes and guide comments throughout monitoring years 1996-2007.

Study Locations

Since 1996 the AAB program has studied an average of 38 beaches per year from within three *critical reaches* of the river corridor (Figure 1). The practice of assessing camping beach resources within critical reaches was first developed by Kearsley and Warren (1993), and modified for the 1996 Adopt-a-Beach study by Thompson and others (1997). A critical reach is defined as a section of the river where camps are in high demand and few in number. The same reach system has been in use for all years of study, 1996-2007. They are as follows: 1) Marble Canyon, river miles 9-41; 2) Upper Granite Gorge, river miles 71-114; and 3) Muav Gorge, river miles 131-165.

Two new critical reaches were added for the 2003 monitoring season. The purpose is to increase the sample set of beaches in order to more widely represent the effects of beach erosion and building throughout the whole river corridor below Glen Canyon Dam. These new reaches included Glen Canyon, from the dam to Lees Ferry (river mile 0), and Lower Granite Gorge, from Diamond Creek (river mile 226) to Gneiss Canyon (river mile 236). Unfortunately, no data was available for the Glen Canyon reach for this report, but the Lower Gorge reach is included.



 Defines a critical reach for campsite beaches along the Colorado River

Figure 1. Locations of five critical reaches in Grand Canyon National Park.

Table 1 shows popular campsites (n = 44), many of which were originally inventoried in 1996, and include beaches added in 2000 and 2001. Every beach in the inventory has an established photographic location that shows an optimum view of the beachfront and as much of the actual camping area as possible. Each year, GCRG motivates guides to adopt as many beaches as possible. To encourage a relatively complete data set from year to year, GCRG encourages adoption of high-priority beaches (n = 27) first. These beaches have been adopted for most of the study years. Usually, they are camps that can be used year after year by the river community, and thus are continually in high demand. The remaining beaches are adopted once high-priority beaches have been claimed.

The number of adopted beaches with useable data in 2006 totaled 43. This is an increase by 6 over the number adopted in 2005. 2007 had a 100 % adoption rate, with 44. Each record in the data base represents an individual visit to a beach where each beach has 1-5 photos associated with it. As encouraged by other Grand Canyon researchers, several adopters took extra snapshots of various episodes such as flash flooding in Schist Camp (August 2002) and Last Chance Camp (August 2001) and debris flows at Hot Na Na (July 2000). These documented events and data are available to any interested researchers through Grand Canyon River Guides or Grand Canyon Monitoring and Research Center. Part of the Adopt-A-Beach program is to provide photos of unusual natural events in Grand Canyon to interested parties.

The time-series photos taken within study locations allow assessment of relative change over the course of each season and between monitoring years. Assessment is standardized according to the highest average fluctuating flow of the season and to a zone of 20,000 cfs when comparing 1996 photos (determined by Kaplinski and others 1994). From year to year GCRG assesses the number of beaches that change in size and evaluates campsite space up to the 45,000 cfs zone, the level of the 1996 BHBF.

Glen Canyon		Marble Canyon		Upper Granite Gorge		Muav Gorge		Lower Granite Gorge	
Mile	Camp	Mile	Camp	Mile	Camp	Mile	Camp	Mile	Camp
-13.0	Dam Beach	11.0	Soap Creek	15.6	Below Nevils	131.1	Below Bedrock	235.1	Travertine
-8.0	Lunch Beach	12.2	Salt Water Wash	76.6	Hance	132.0	Stone Creek	240.0	Gneiss
		16.3	Hot Na Na	81.3	Grapevine	133.0	Talking Heads		
		19.1	19 Mile	84.0	Clear Creek	133.5	Race Track		
		20.4	North Cyn	84.5	Zoroaster	133.7	Lower Tapeats		
		23.0	23 mile	91.6	Trinity	134.6	Owl Eyes		
		29.3	Silver Grotto	96.0	Schist	137.0	Back Eddy		
		34.5	Middle Nautiloid	96.7	Boucher	143.2	Kanab		
		34.7	Lower Nautiloid	98.0	Crystal	145.6	Olo		
		37.7	Tatahatso	99.7	Tuna	148.5	Matkat Hotel		
		38.3	Bishop	107.8	Ross Wheeler	150.3	Upset Hotel		
		41.0	Buck Farm	108.3	Bass	155.7	Last Chance		
				109.4	110 Mile	164.5	Tuckup		
				114.3	Upper Garnet	166.4	Upper National		
				114.5	Lower Garnet	166.6	Lower National		

Table 1. Sample set of camping beaches inventoried that lie within five critical reaches.

Analysis

Data are analyzed according to the particular research questions asked for that year. For this study, the data are grouped into four temporal categories, the first beginning with mid- October, 2005 and ending in mid-April 2006. Corresponding dates for the years 2006 and 2007 were also grouped. The second category was composed of groups containing the entire photo set for an individual year, both 2006 and 2007.
The third category of analysis utilized the last photo date of the year, 2006 and 2007 respectively, and compared this data to the photo data collected most recently, but prior to, the March 1996 BHBF. When a comparison photo was available, it was almost always acquired a few days before the BHBF event. The fourth category of analysis utilized the final photo data collected in the years 2006 and 2007 and compared it to the most recent data available which predated the November HFE event in 2004.

When comparing the photos for evaluation, 8 criteria were used to gather the empirical data used. These included estimating the river flow in each of the photos, usually confirmed by flow data available through the Grand Canyon Monitoring and Research Center (GCMRC) website, and standardizing the beach configuration to the highest dam release summer flow, just over 15,000 cfs. Also considered was any evidence of any flattening, mounding or scouring of sand in the photos, a change in area of sand cover between photo dates, vegetation cover, rocks covered/uncovered by the flow changes or wind action that would indicate a change in camping area, a change in the loading/unloading areas used by river parties who stop to lunch or camp at the beach, and comments made by the AAB photographer on the datasheet when the photo is taken. Due to the variety of river flow levels between the comparison photos, change in the 'parking' at a particular beach was usually difficult to evaluate, and often was considered only when recorded by the AAB observer. Knowledge of the study sites by this investigator were also considered, though this did not determine the final classification used for any particular beach. Using these criteria, the beaches were given classifications indicating sand deposition as Increase, Decrease or No Change. If 2 or 3 of the criteria, depending on the significance of the observation, indicated a change in the beach condition between the photos, the beach was classified as either "Better camping", or "Worse camping". Otherwise, a classification of "Same" was used for that beach.

A comparison was also made between the first and last dated photos of each temporal category group and the final classification was determined by the overall activity at the individual beach for all grouped photo dates.

For the third and fourth categories of analysis, beach photos and comments were evaluated to determine changes from any factors. This evaluation resulted in beach classifications of No Change (Same), an Increased Desirability for Camping (Better) or Degraded Desirability for Camping (Worse). The 'Degraded' classification was then subdivided by perceived cause.

Results of this classification process are presented in tabular format. See Tables 2 & 3 in the Appendix B.

RESULTS

Analysis for Pre Summer Seasonal Flows for 2006 and 2007

For the purposes of this portion of the analysis, only photo and datasheet information obtained between mid-September and late April is being considered. Constriction to this time frame is meant to isolate Spring and late monsoonal tributary influences and to more specifically analyze the Winter High Fluctuating Flows (WHFF).

By limiting the applicable photo dates, the portion of available data for this analysis is seriously restricted. Of the 43 beaches in consideration for the entire year 2006, only 24 are used. Likewise, of the 44 beaches used in the 2007 analysis, only 20 are qualified for consideration.

Of the 24 beaches considered in the 2005 - 2006 winter period, 20 (83%) were found to be virtually the same in size and configuration as in the same time period of 2005. The other 4 (17%) beaches had degraded and were considered as in Worse condition than at the end of 2005. One of these beaches experienced a tributary flash which removed campable area, and 3 had sand loss believed to be the result of erosion from river flows. The breakdown by reach for this period included: Reach 2 had 4 Same and 2 Worse classifications; Reach 3 contained 8 Same designations, and Reach 4 had 8 Same and 2 Worse classifications. No qualified data was found for either beach in Reach 5.

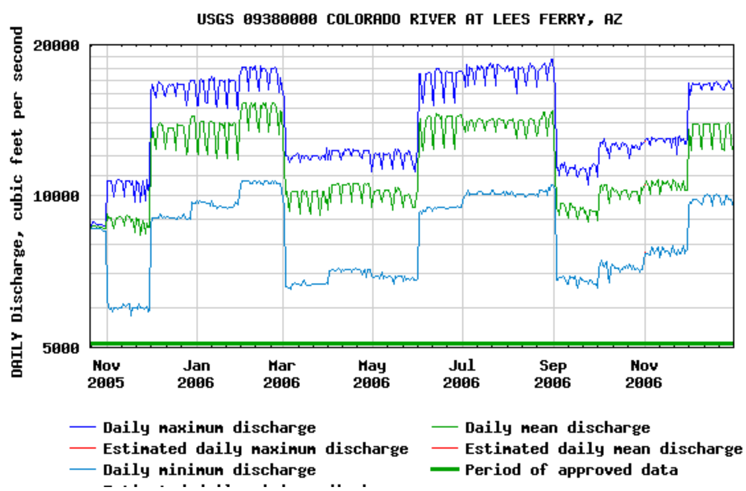


Fig 2. Hydrograph of Colorado River as measured at Lees Ferry, Az, Nov.2005 through Dec. 2006. Graph downloaded from USGS website.

Of the 20 beaches analyzed for the winter of 2006-2007, 16 (80%) were not significantly changed and received a Same evaluation as the similar time period the previous year. Again, 4 beaches, now 25%, had perceived degradation and were considered Worse than before. All 4 were deemed degraded due to river fluctuation flows. Additionally, 3 exhibited gullying by rain events and 1 was also impacted by a vegetation increase. Per Reach; Reach 2 contained 6 Same and 2 Worse classifications; Reach 3 had 3 Same designations and 1 Worse; Reach 4 contained only Same classifications with 6; and Reach 5 contained 1 Same and 1 Worse designation.

Neither winter season had beaches which showed an improvement, qualifying for Better status.

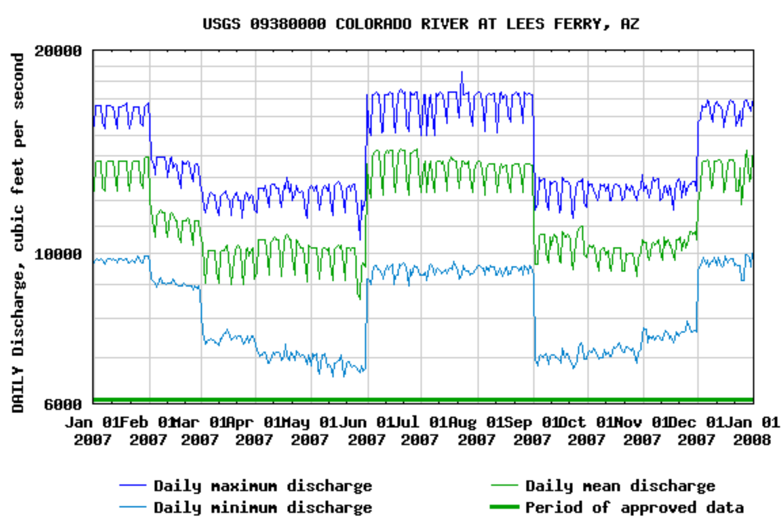


Fig 3. . Hydrograph of Colorado River as measured at Lees Ferry, Az, Jan. through Dec. 2007. Graph downloaded from USGS website.

Analysis for Year-long Comparisons in 2006 and 2007

In the year 2006, those beaches which had 2 or more photo dates and/or datasheets, allowing for temporal analysis totaled 36. Those without significant change, and therefore receiving a Same classification, totaled 26 (72%). This included 6 in Reach 2, 8 in Reach 3, 12 were found in Reach 4 and 1 was located at RM 230, in Reach 5.

Four beaches, or 28 % of the yearly total, received a Worse designation. The most often reason cited is rain or tributary flash related erosion. These events ranged in size, but all had enough impact to degrade the beach. Reach 2 contained 5 beaches receiving a Worse classification; Reach 3 had 3; 1 beach with a Worse designation was found in Reach 4; and 1 was located in Reach 5.

Of the 44 total beaches considered in the AAB program, 38 qualified for analysis during the 2007 year. It should be noted that all 44 beaches were photographed or had datasheets submitted during 2007, but not all had enough information submitted for temporal comparison on all beaches.

2007 showed a decrease, compared to 2006, in beaches receiving a Same designation when evaluated for yearly change. Of the 38 beaches considered, 20 (53%) remained stable throughout the year. 5 (13%) of the beaches were classified as Better, showing improvement through the yearly comparison. The almost unanimous reasoning for the improvement was a reworking of the beach that spread more sand into the boat parking/loading and unloading area. No particular cause was expressed on datasheets nor could be ascertained from the photos.

A total of 13 (34%) beaches were considered to degrade throughout the year and received a Worse classification. The most often cited reasons, in order, included erosion from river flow fluctuations; rain caused erosion forming gullies, and an increase of vegetation in the camp area. The distribution of these degraded beaches was not equitable, with Reach 2 having 2 beaches with a Worse designation; 2 were located in Reach 3; Reach 4 contained 8 of these beaches, for almost 62 %; and 1 was contained in Reach 5.

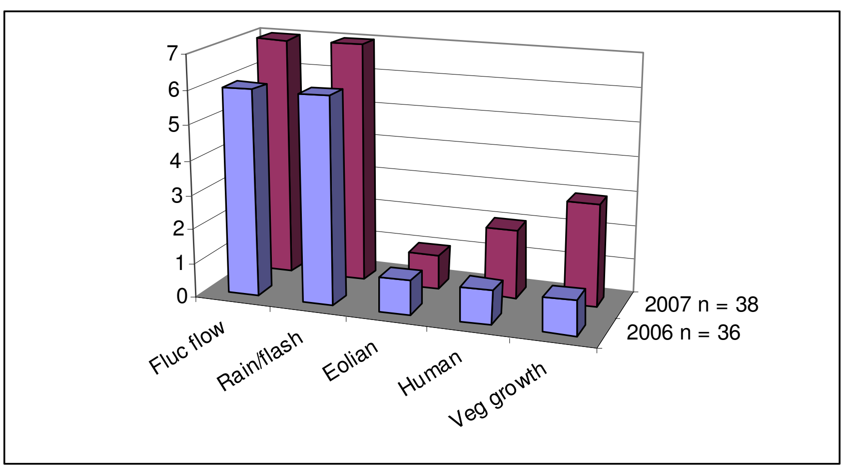


Fig 4. Year to Year Comparison of Primary Degradation Factors, 2006 & 2007

Comparison of 2006 and 2007 Beaches to Pre 1996 BHBF.

Two of the most basic and perplexing questions addressed by this study are: 1. Are BHBF events successful in their attempt to improve a beach from the boating/camp users perspective, and 2. How long do the effects of a BHBF event last? To help gain perspective on answers to these questions, two additional analyzes were conducted on the 2006 and 2007 data. The first is a beach by beach comparison of the latest known photos to photos taken shortly before the 1996 BHBF.

For the 2006-pre1996 comparison, photos and data on 34 beaches were analyzed. Of the 44 beaches in the study, only 1, Upset Hotel, did not have photographic recording of the beach conducted in 2006. However, not all of the current beaches studied were photographed prior to the 1996 BHBF. The reader is advised that a strict Reach to Reach comparison is not helpful because 4 of the 12 beaches in Reach 2 could not be compared, as was 1 of the 15 beaches in Reach 3 and 1 of the 14 beaches found in Reach 4. With the conclusion of 2006, 20 of the 34 beaches, had a designated classification as Same. Regardless of the outcomes of the preceding 1996 and 2004 BHBF events, 59 % of the beaches analyzed showed no effect for the 10 intervening years. Further broken down, Reach 2 contained 3 of those beaches, Reach 3 had 7, and 10 were located in Reach 4. Neither of the beaches found in Reach 5 and used in this study were photographed in 1996. In other words, 3 of 8 in Reach 2, 7 of 13 in Reach 3, and 10 of 13 in Reach 4 received Same classification.

Of the 34 beaches included in 2006, 7 beaches are classified as Better than they were when photographed in 1996. So, just over 20 % have supposedly benefited from the BHBF events, though this is not to say that all of the beaches referred to here have maintained the same degree of improvement. The distribution of these beaches found 2 in Reach 2, Reach 3 contained 4, and Reach 4 had 1 of the improved beaches.

Concluding the 2006-pre1996 analysis, 7 beaches, or just over 20 %, were designated as Worse when compared to the pre1996 BHBF. These were evenly distributed through the 3 reaches concerned, with 2 of 8, found in Reach 2, 2 of 11 in Reach 4 and 2 of 13, located in Reach 4.

The comparison of the 2007 yearly data with the pre-1996 photos yields slightly different results. For the year 2007, a total of 36 beaches were used. Again, 4 of the beaches located in Reach 2 are without 1996 photos, as are 1 in Reach 3, 1 in Reach 4 and neither of the two contained in Reach have 1996 counterparts.

Of the 36 beaches, 5 in Reach 2, 6 in Reach 3 and 6 found in Reach 4 were classified as Same as photographed in 1996. This accounts for 5 (63 %) of 8, in Reach 2; 6 (38 %) of 13 found in Reach 4; and 6 (40 %) of 15 in Reach 4, and a total of 47 % of the beaches throughout the river corridor.

As in 2006, 7 beaches were designated as Better than when they were photographed in 1996. 4 of these beaches are located in Reach 3 and 3 in Reach 4. For Reach 3 this accounts for 31 %, and in Reach 4, 20 %.

Interestingly, between 2007 and 2006, not all of the beaches considered as improved conditions from 1996 match. In a couple of cases, the change was produced by a gradation of the cutbanks in 2007. More often, rocks found in the main camp, particularly towards the rear of the camp, were covered by sand in 2007. This does not indicate that the rocks were moved. To the contrary, the rocks and vegetation observed were specifically picked for their stability. However, eolian processes at many beaches are well documented. Most often it presents by dune buildup to the rear or sides of the camps. Reworking of the sand already in place at these beaches could certainly account for the seeming increase in camp size, particularly when the camp area is well above the fluctuating flows.

Finally, there were a total of 12 beaches designated as Worse when compared to the 1996 photos. 3 were located in Reach 2, 3 in Reach 3 and 6 in Reach 4 for 38 %, 23 % and 40 % respectively. This is an increase by 5 from the 2006 comparison, from 20 % up to 33 %.

As a brief comparison, the 2005 AAB study, immediately following the 2004 BHBF, reported 16 (46%) were classified as Same, 14 (40%) as Better, and 5 (14%) were considered Worse (Lauck, 2006).

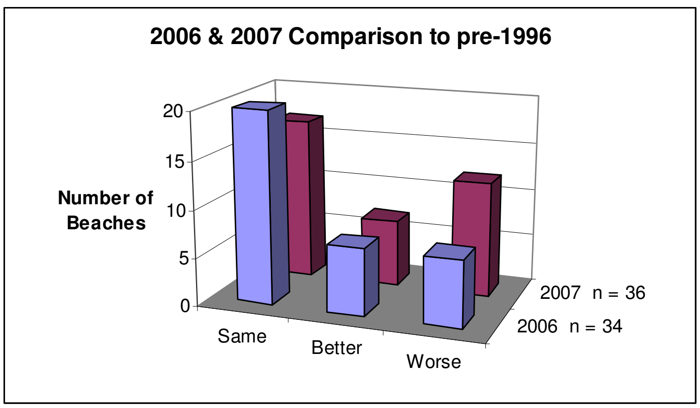


Fig. 5. Comparison of pre-1996 Beach Classifications Between Years

Results of Comparison Between 2006 and 2007 Year-end and pre-2004 HFE

The 2004 HFE is the most recent High Flow event to which the current photos can be compared. Just as the pre-HFE 2004 data was compared to the 1996 event for evidence of longevity, analysis of the beach status since the HFE may help better define the overall results of the high flow events (Thompson, Pollock 2006).

This examination included 43 of the 44 AAB study beaches in 2006. Comparison revealed 27 of the beaches were essentially the Same as in early 2004 after the BHBF. 63 % of the beaches overall. This subdivided into 7 (58 %) of 12 for Reach 2. There were 10 (67 %) of 15 total classified as Same in Reach 3,and 9 (64 %) of 14 in Reach 4. Additionally, 1 (50 %) of 2 found in Reach 5 were considered as Same.

5 of the 43 beaches were found in 2006 to have a Better rating compared to the 2004 data. Of this 12 %, 2 of 12 were Better in Reach 2, 2 of the 15 located in Reach 4

received a Better designation, and 1 of the 14 in Reach 4. No Better ratings were given to the beaches in Reach 5. This is also read as 17 % in Reach 2, 13 % in Reach 4 and 7 % of Reach 4. Improved parking at the beach front was most often cited as the reason for a Better designation, possibly indicating that cutbanks created shortly after the BHBF in 2004 had graded and made boat parking and loading/unloading of guests and equipment easier and more comfortable. Increased camp size, again most likely by the reworking of sand deposited in 2004, was also a contributing reason.

Lastly, 11 of the 43 beaches garnered a Worse than 2004 rating for 2006. That is, almost 26 % of the total beaches considered in 2006 were less attractive to boaters than in 2004. The most prevalent reason for the degradation of the beaches was rain induced flash flows creating gullies in the camp proper. This was closely followed, or, in some cases, accompanied by, erosion from fluctuating river flows. Increase of vegetation in the camp was also noted. Broken down by reach, 3 of the 8 beaches in Reach 2, or 38 % were Worse. 20 % of the beaches in Reach 3, 3 of the 15, were Worse. And 4 (29.5 %)of the 14 total in Reach 4, and 1 (50 %) of the 2 in Reach 5 were classified as having degraded relative to their pre-BHBF counterparts.

Similarly, 44 beaches were used in the comparison with 2007 data. Of the 44 beaches compared, 20 (45 %) are considered to be the Same as the pre-BHBF 2004 beaches. A total of 7 (16 %) of the 44 are designated as Better and 17 (39 %) are rated as Worse. As with the 2006 results, most of the Better designations were cited as the result of gradation of beach fronts and continued dispersion of sand. Slightly more than half of the 17 beaches receiving a Worse rating had degradation from rain caused gullies as the primary negative impact. Again, river fluctuation caused erosion and increased vegetation cover in camp were also factors.

By reach, this included 6 of the12 in Reach 2, 7 of 15 in Reach 3, 6 of the 15 located in Reach 4 and 1 of the 2 in Reach 5.

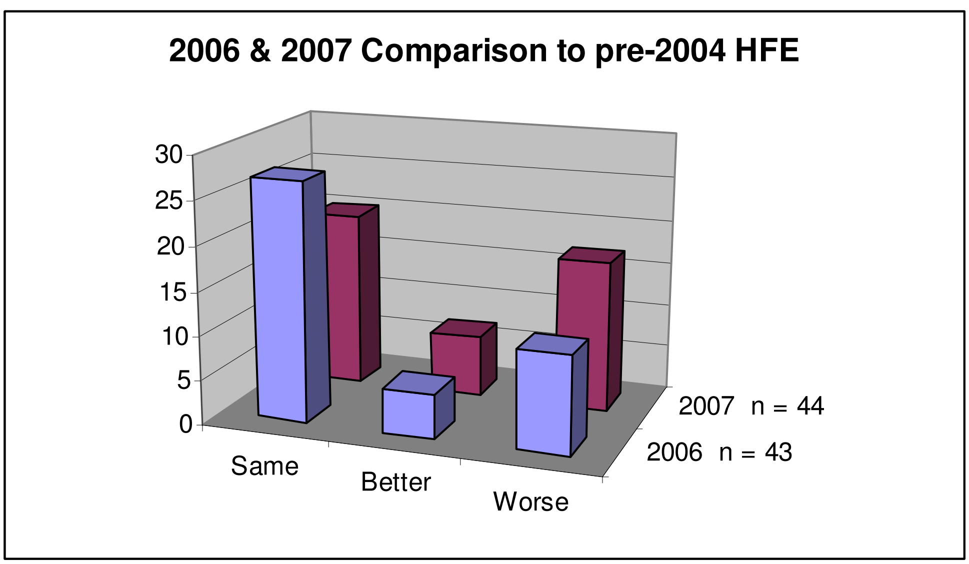


Fig 6. Comparison of pre-2004 Beach Classifications Between Years

CONCLUSIONS

The results of this study since 1996 are generally consistent with those presented by other authors and agencies in the past. Following BHBF and HEF events, beaches have continued to decrease in size and acceptability as time passes. Degradation of beaches occurs throughout the year, with the greatest impacts closely following a BHBF or HMF event (O'Brien, 2000; Lauck, 2007). However, the annual decrease in the magnitude of beach loss and degradation of camps (Hazel and others, 2002) appears to apply primarily to erosion associated with fluctuating flow patterns. Of greater importance for the years of 2006 and 2007, recorded by the photos and reports from volunteers, was the beach erosion created by rain washed gullies through camps. For the two years, 16 beaches were seriously degraded by flash events, and at least two other rain related events of lesser impact were noted.

As demonstrated throughout the 10 years of this project, some beach fronts, regardless of reach, become static and beach front erosion becomes almost mute. Two examples of this are Tatahatso, RM 37.7L and Racetrack, RM 133.5R. At these camps, once the sand has achieved an angle of repose at the landing areas, the effects of dam release flows appear to be minimal. Impact from human caused erosion, mostly at boat parking locations, have not become discernable. Other beaches, such as Silver Grotto, RM 29.3L, Stone, RM 132.0R and Gneiss, RM 236.0R are continuously reduced, to varying degrees, by wave action stimulated by fluctuating flows. Vegetation encroachment into camp areas, eolian action and human impacts are usually slower to produce noticeable changes. However, it was the frequency of flash events and the sudden, and not usually subtle results, that generated the most concern for these two years. Most importantly, major rain events are not limited to a particular reach and cannot be regulated by dam releases.

Fig 7. Main camping beach at Matkat Hotel, RM 148.5L after second monsoonal flash. Photo taken Nov. 2006

Wind reworking of beaches, particularly in non-vegetation stabilized areas above normal flow releases, were also recognized. Dune buildup at the margins of camp areas, especially at the back of beaches, was pronounced. Presumably this was accentuated by the increase of sand available for transport following the 2004 BHBF. A field check proved that rocks at Lower Tuna camp, RM 99.7L, had been exposed by eolian sand transport by as much as 455mm. However, for the two years examined in this study, no beach/camp has been reclassified negatively due to eolian affects. Indeed, some camps were considered as improved and enlarged by the possible reworking of the sand through eolian action. The eolian processes are still considered to be important parameter worth careful consideration in the future.

At least one beach, Soap Creek, RM 11.0R, displayed an upgrade in status as the probable result of deposition by the Paria river during a flood flow before July 13th, 2007. The low lying beach front had evidence of new sediment deposit, and the color of the beach closely matched the river color, still running with Paria runoff. Other flood events from the Little Colorado drainage during August and September of 2007 may also have influenced beach evaluations, and appeared as notes on datasheets recorded by guides.

Implementation of BHBF or HMF events, when sufficient sediment is available in the system, appear essential for the continued maintenance of beaches in the Grand Canyon. Deposition of sand in the camp areas above the 30000 cfs flow line are particularly important to replenish sand that has been removed from the beach by rain and wind activities.

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Grand Canyon River Guides, Inc. would like to thank all of the adopters for volunteering the time to pull over and photograph their beaches and for their valuable observations and written comments. It takes time and effort to do this, and the dedication shown by guides has literally kept this program alive for ten plus years. The result is the most comprehensive collection of repeat photographs of critical camping beaches in the Grand Canyon. An added benefit is the public outreach fostered by the volunteers actions. By taking time to include guests as active participants and by answering their questions, volunteers can further explain how our resource in Grand Canyon is enhanced, degraded or maintained by the influence of man and technology.

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Appendix A

Adopt-A-Beach Data Sheet
Used by Volunteers to Record Comments

Adopt a Beach Data Entry Form

Guide's Name ______________________

Camp Name ______________________

Camp Mile ______________________

Date ______________________

River Flow (circle one) Low (5-12K) Med (12-18K) High (18-25K)

Photo Numbers: ______________ (remaining)

Any Comments about Beach Change? (describe in this space)

Change in Beach Size from Previous Visit (circle one): Increase Decrease Same

Dominant Cause of Change (circle one):

Spike	Daily/Monthly Flow	Rain	Wind	People	Don't Know

Supporting Observations for Dominant Cause (check any that are appropriate):

- New cutbank
- Change of slope
- Bench in eddy
- Gully
- Trib/Debris flow
- Scour from wind or people
- Mounded sand

Secondary Cause of Change (circle one):

Spike	Daily/Monthly Flow	Rain	Wind	People	Don't Know

Supporting Observations for Secondary Cause (check any that are appropriate):

- New cutbank
- Change of slope
- Bench in eddy
- Gully
- Trib/Debris flow
- Scour from wind or people
- Mounded sand

Campsite Quality Compared to Last Visit (circle one): Same Better Worse

Supporting Observations for Campsite Quality (check any that are appropriate):

- Boat parking
- Rockiness
- Vegetation encroachment
- Steepness
- Trail erosion
- Open sand area
- Human impacts- ants, pee spots, litter (circle those that apply)

Any Comments about Campsite Condition? (describe in this space)

Did you camp here this visit? Yes No How many people in your group? _____

If you camped here, does it feel crowded or comfortable, given this water level & group size?

Considering the campsite quality factors, and the above restriction against camping in the Old High Water Zone, what would a good group size be for this camp at the current water level?

____

Appendix B

Results of Analysis in Tabular Form

2006 Season																			
Camp name	River mile	2006	to	2005	reason	2006	all	year	reason	2006	to	pre 04	reason	2006	to	pre 96	reason	Camp name	River mile
		same	better	worse		same	better	worse		same	better	worse		same	better	worse			
Soap	11.0	X				X			though Paria may add	X							no photo 96	Soap	11.0
Salt Water Wash	12.2	X						X	gully erosion and veg	X			does gully effect camping				no photo 96	Salt Water Wash	12.2
Hot Na Na	16.3	X						X	rvr fluc		X		sand covers rocks				no photo 96	Hot Na Na	16.3
19 Mile	19.1	O			No early 06	X				X							no photo 96	19 Mile	19.1
North Canyon	20.4	O			No early 06	X					X		more camping, better parking		X		more sand, flatter	North Canyon	20.4
23 mile	23.0	O			No early 06				no seasonal photos	X				X				23 mile	23.0
Silver Grotto	29.3		O		No early 06	X						X	gullies, less sand	X				Silver Grotto	29.3
Middle Nautaloid	34.5			X	flash erosion	X				X			parking still sucks			X	flash removed parking	Middle Nautaloid	34.5
Lower Nautaloid	34.7			O	No early 06			X	flash and rvr fluc	X						X	worse parking	Lower Nautaloid	34.7
Tatahatso	37.7			X	steeper landing			X	steeper landing			X	steeper landing, cutbank	X				Tatahatso	37.7
Bishop/Martha's	38.3	O			No early 06			X	big flash thru camp			X	less sand, steeper, GULLY			X	gully, steeper landing	Bishop/Martha's	38.3
Buck Farm	41.0	X				X				X					X		graded sand, parking +	Buck Farm	41.0
		4	0	2		6	0	5		7	2	3		3	2	3			
Nevill's	75.2	O			No early 06				no seasonal photos	X			Camp has moved	X				Nevill's	75.2
Hance	76.6	X				X				X				X				Hance	76.6
Grapevine	81.3	X				X						X	less camping area from erosion, veg				no photo 96	Grapevine	81.3
Clear Creek	84.0	O			No early 06			X	new gully cut in camp			X	new gully in camp		X		better parking, more sand	Clear Creek	84.0
Zoroaster	84.4		O		No early 06			X	rvr fluc	X					X		more sand in back	Zoroaster	84.4
Trinity	91.6	X				X				X			new gully at parking				photos don't match	Trinity	91.6
Schist	96.0	X							no seasonal photos			X			X		more sand	Schist	96.0
Boucher	96.7	O			No early 06	X				X						X	veg and aeolian dunes	Boucher	96.7
Crystal	98.0	O			No early 06				no seasonal photos	X			steeper at front			X	rocky parking, steeper	Crystal	98.0
Lower Tuna	99.7	O			No early 06			X	rvr and wind erosion	X			better camping, steeper landing	X				Lower Tuna	99.7
Ross Wheeler	107.8	X				X				X				X				Ross Wheeler	107.8
Bass	108.3	X							no seasonal photos	X			not graded as of last photo	X				Bass	108.3
110 mile	109.4	O			No early 06	X				X				X				110 mile	109.4
Upper Garnet	114.3	X				X					X		better parking	X				Upper Garnet	114.3
Lower Garnet	114.5	X				X					X		better parking		X		more sand for camp	Lower Garnet	114.5
		6	0	0		8	0	3		10	2	3		7	4	2			
Below Bedrock	131.1	O			No early 06	X			sand loss at upr and lwr		X		better parking			X	less sand, more veg	Below Bedrock	131.1
Stone	132.0	X				X				X				X				Stone	132.0
Talking Heads	133.0	O			No late 05	X				X				X				Talking Heads	133.0
Racetrack	133.5	O	X		No early 06				no seasonal photos	X					X		better parking, more sand	Racetrack	133.5
Lower Tapeats	133.7			X	less sand at parking	X				X			No Camp	X				Lower Tapeats	133.7
Owl Eyes	134.6	X				X				X				X				Owl Eyes	134.6
Backeddy	137.0	X				X				X				X				Backeddy	137.0
Kanab	143.2	X				X				X				X				Kanab	143.2
Olo	145.6	X				X						X	Big flash again - still no camp				no photo 96	Olo	145.6
Matkat	148.5	X				X						X	new gully in camp	X				Matkat	148.5
Last Chance	155.7	X						X	flash took some sand			X	flash removed sand	X			slightly less sand	Last Chance	155.7
Tuckup	164.5	X				X			small gully	X				X				Tuckup	164.5
Upper National	166.4			X	less sand in camp	X				X			esthetically better	X				Upper National	166.4
Lower National	166.6	O			No early 06	X						X	less camping area from erosion, veg			X	more veg, less camp	Lower National	166.6
		8	0	2		12	0	1		9	1	4		10	1	2			
Travertine Falls	230.0	O			No early 06	X				X							no photo 96	Travertine Falls	230.0
Gneiss	236.0			O	No early 06			X				X	Erosion from river fluc.!!!				no photo 96	Gneiss	236.0
		0	0	0		1	0	1		1	0	1		0	0	0			
Totals	43	20	0	4		26	0	10		27	5	11		20	7	7			

2007 Season																			
Camp name	River mile	2007	to	2006	reason	2007	all	year	reason	2007	to	pre 04	reason	2007	to	pre 96	reason	Camp name	Rvr Mile
		same	better	worse		same	better	worse		same	better	worse		same	better	worse			
Soap	11.0		O		No late 06	X			rvr flucuation		X		Paria flow ?				no 96 photo	Soap	11.0
Salt Water Wash	12.2	X				X			rvr flucuation			X	gully, more veg				no 96 photo	Salt Water Wash	12.2
Hot Na Na	16.3	X						X	Flash, new gully			X	new gully				no 96 photo	Hot Na Na	16.3
19 Mile	19.1	O			No late 06	X				X							no 96 photo	19 Mile	19.1
North Canyon	20.4	O			No early 07	X			sand shift toward river	X				X			large veg increase though	North Canyon	20.4
23 mile	23.0	O			No early 07				no compare for 07	X				X				23 mile	23.0
Silver Grotto	29.3			X	rvr flus and gullies			X	gullies, ero, steeper			X	new gullies			X	rain gullies and rvr fluc	Silver Grotto	29.3
Middle Nautaloid	34.5	X				X				X				X				Middle Nautaloid	34.5
Lower Nautaloid	34.7	X			slight sand loss		X		slight sand + at park			X	parking degraded			X	less sand at parking	Lower Nautaloid	34.7
Tatahatso	37.7	X				X			slight loss by erosion/veg	X				X				Tatahatso	37.7
Bishop/Martha's	38.3			X	cutbank, rain gully		X		gully, cutbank mellowed			X	huge gully in camp			X	gully through main camp	Bishop/Martha's	38.3
Buck Farm	41.0	X				X				X				X			camp same, but less sand	Buck Farm	41.0
		6	0	2		7	2	2		6	1	5		5	0	3			
Nevill's	75.2	O			No early 07	X			camp moved?	X				X			more veg	Nevill's	75.2
Hance	76.6	O			No late 06				no compare for 07	X				X			more veg	Hance	76.6
Grapevine	81.3			O	No early 07	X						X	wind erosion, more veg				no 96 photo	Grapevine	81.3
Clear Creek	84.0	X				X						X	veg increase			X	much more veg	Clear Creek	84.0
Zoroaster	84.4			X	rvr fluc, veg increase		X		plus at landing, bigger	X				X			less sand, more veg	Zoroaster	84.4
Trinity	91.6	X						X	gullies, river erosion	X							could not match photos	Trinity	91.6
Schist	96.0	O			No early 07			X	gully bigger, people impact	X					X		better parking, bigger camp	Schist	96.0
Boucher	96.7	X			noticable wind effect	X				X					X		more sand in camp	Boucher	96.7
Crystal	98.0	O			No early 07	X				X				X				Crystal	98.0
Lower Tuna	99.7	O			No late 06 (wind effect)				no compare for 07		X		more sand in camp			X	degraded parking, more veg	Lower Tuna	99.7
Ross Wheeler	107.8	O			No early 07		X		better parking		X		more sand in camp	X			more sand, but more veg	Ross Wheeler	107.8
Bass	108.3	O			No early 07	X						X	rvr fluc	X				Bass	108.3
110 mile	109.4	O			No late 06				no compare for 07			X	less beach, more veg			X	much more veg	110 mile	109.4
Upper Garnet	114.3			O	No early 07	X					X		more sand in camp		X		more sand in camp	Upper Garnet	114.3
Lower Garnet	114.5	O			No early 07		X		slight + landing			X	gully in camp		X		more sand in camp	Lower Garnet	114.5
		3	0	1		7	3	2		7	3	5		6	4	3			
Below Bedrock	131.1	X				X				X				X				Below Bedrock	131.1
Stone	132.0	O			No early 07	X			flucuates a lot		X		more sand in camp			X	much less sand	Stone	132.0
Talking Heads	133.0	X						X	sand loss, rvr erosion			X	rvr fluc		X		more sand in camp	Talking Heads	133.0
Racetrack	133.5	O			No early 07	X			lots of flucuating		X		more sand in camp		X		more sand in camp	Racetrack	133.5
Lower Tapeats	133.7	O			No early 07	X				X			can not get worse			X	less sand at parking, camp	Lower Tapeats	133.7
Owl Eyes	134.6	X						X	cutbanks, steeper	X				X			slight veg increase	Owl Eyes	134.6
Backeddy	137.0	O			No late 06				no compare for 07			X	steeper parking		X		no more cutbank at parking	Backeddy	137.0
Kanab	143.2	O			No early 07			X	more vegl	X				X				Kanab	143.2
Olo	145.6	O			No early 07			X	more flashes, less sand			X	flashes cover beach			X	flashes cover beach	Olo	145.6
Matkat	148.5	O			No late 06			X	gully +, smaller camp			X	gully through main camp			X	gully through main camp	Matkat	148.5
Upset Hotel	150.3			O	No early 07					X				X			still terrible parking	Upset Hotel	150.3
Last Chance	155.7	X						X	more rain, less sand			X	smaller from flashes			X	smaller from flashes	Last Chance	155.7
Tuckup	164.5	X				X			slight gully	X				X				Tuckup	164.5
Upper National	166.4	X						X	veg up, beach loss		X		parking on gentle slope	X			veg increase	Upper National	166.4
Lower National	166.6	O			No late 06			X	more veg in camp			X	veg increase			X	much more veg	Lower National	166.6
		6	0	0		5	0	8		6	3	6		6	3	6			
Travertine Falls	230.0	X						X	loss from rvr erosion	X							no 96 photo	Travertine Falls	230.0
Gneiss	236.0			X	rvr fluc, gullies	X			slight gully			X	rvr fluc & rain gullies				no 96 photo	Gneiss	236.0
		1	0	1		1	0	1		1	0	1		0	0	0			
Totals	44	16	0	4		20	5	13		20	7	17		17	7	12			